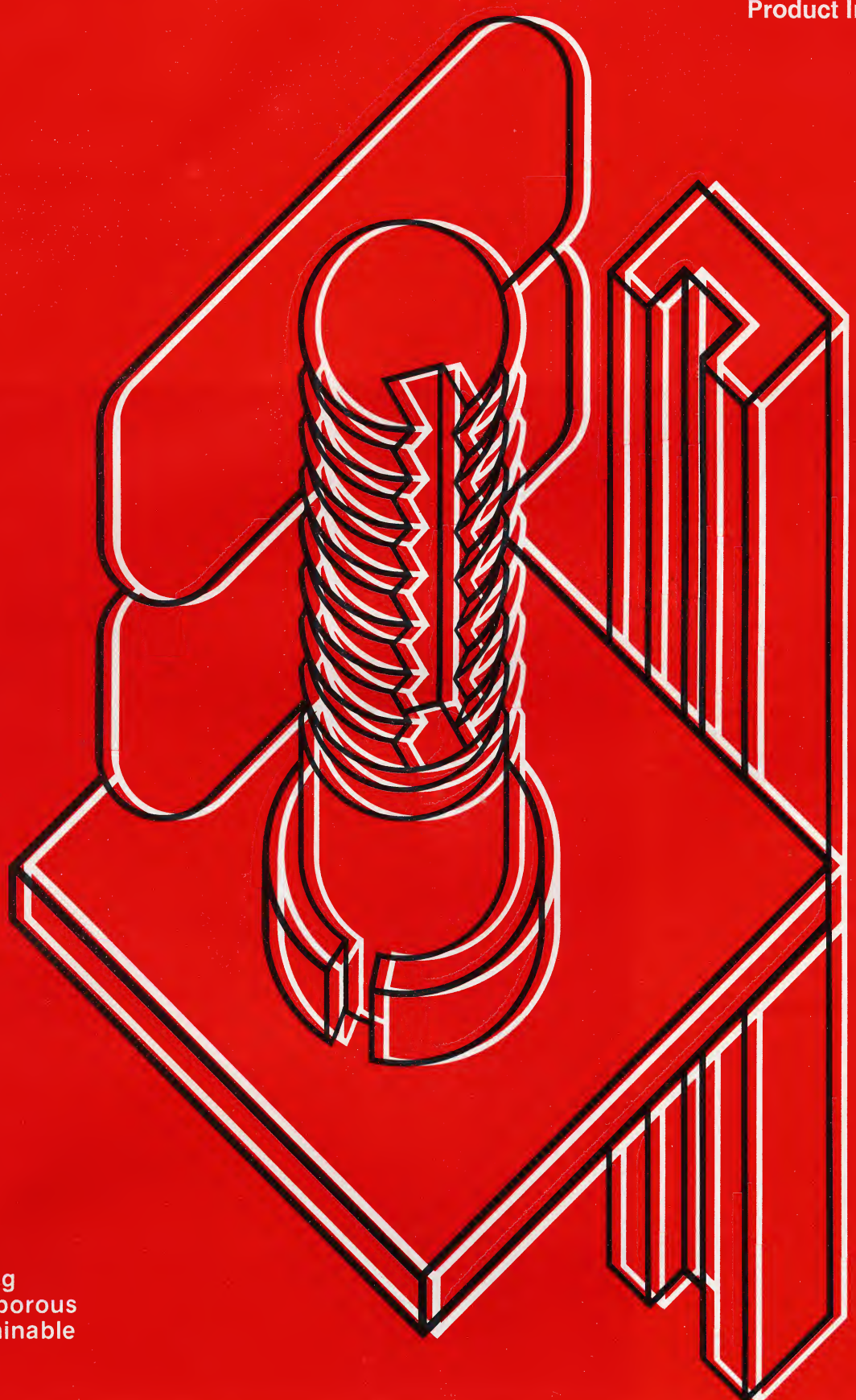
CORNING

MACOR™ Machinable Glass-Ceramic

Product Information



strong
non-porous
machinable

MACOR™ Machinable Glass-Ceramic

Normally glasses, ceramics, and glass-ceramics must be machined using diamond tools. Diamond grinding is expensive and requires special expertise and equipment.

MACOR™ glass-ceramic has a unique, partially-crystalline structure which enables it to be machined to precise tolerances with ordinary metal working tools and equipment.

MACOR™ glass-ceramic does not sacrifice strength, hardness or porosity to achieve this machinability, *nor does it have to be fired after machining*

Now, for the first time, there is a truly machinable insulating material with physical properties that rival those of the best technical ceramics and glasses.

Material Characteristics

MACOR™ glass-ceramic has a combination of properties and characteristics which enable it to be an extremely useful material after it is machined.

Electrical

MACOR™ glass-ceramic is an excellent insulator for high voltage and/or high temperature applications.

- Very high dielectric strength
- High bulk resistivity
- Low loss factor

Mechanical

Mechanical properties are good enough to allow MACOR™ glass-ceramic to qualify for most applications that presently use alumina.

- High strength
- Isotropic and homogeneous
- Dimensionally stable and rigid

Thermal

Thermal characteristics lie between those of ceramic and glass.

- High maximum use temperature
- Moderate thermal conductivity
- High thermal expansion coefficient; can be sealed to common (soda lime) glass

Thermal Shock Resistance

Because of resistance to propagation of cracks, MACOR™ glass-ceramic has a better shock resistance than expected from a high expansion material.

- From 800°C to immersion in ice water, without breakage
- From 200°C to immersion in ice water, without loss of strength

Chemical

Chemical resistance is good although not as good as the best glasses

- Zero water absorption
- Not wetted by molten aluminum, magnesium, tin or copper

Vacuum

MACOR™ materials have been found to be extremely useful, in and around vacuum environments

- Extremely low helium permeation rate
- Does not outgas
- Easily sealed to glass and metal using solder glass

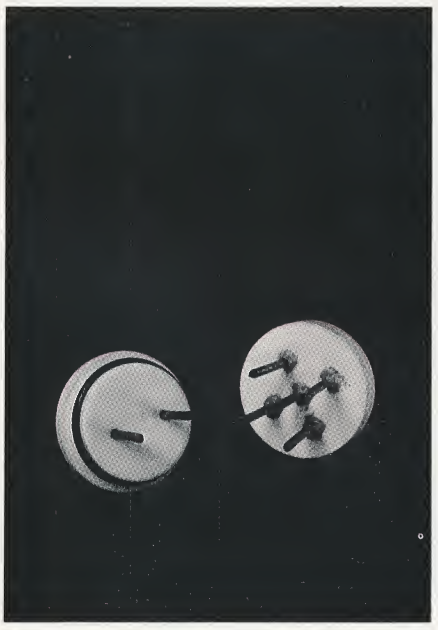
Processing Capabilities

Machining

- Standard metalworking tools and equipment
- Firing is *NOT* required after machining
- Tubes turned with .010" walls
- Hemispheres machined with sphericity of ± .000005"
- Plates ground parallel and flat to ± .00004"
- Holes drilled and tapped (as small as 0-80)
- Tolerances of ± .0005 routinely achieved
- Wafers cut as thin as .005"

Metallization

- Thick film metallization using metal inks (silver, gold and silver/platinum)
- Thin film metallization by sputtering



Sealing & Joining

- Hermetic seals using glass frits good to 800° F
- Strong joints using epoxy
- Mechanical joints utilizing machinability
- Soldered joints on metallized parts

Polishing

- ½μ in AA surface smoothness using cerium oxide on pitch
- 4μ in AA surface smoothness as cut

Physical Properties Code 9658

Property	Test Conditions	Description of Test	Nominal Value	Units
General				
Density	Corrected to 4°C	10 g sample archimedes method	2.52 157	g/cm^3 lb/ft^3
Porosity	25°C	Hg intrusion	0	
Water Absorption		ASTM C-373, boiled in water and dried weight gain.	0	
Helium Permeation Rate	143°C		4.2×10^{-12}	$\frac{\text{cc stp—mm}}{\text{sec cm}^2\text{—cm Hg}}$
Electrical				
Volume Resistivity	25°C d.c.	ASTM C-657	10^{14}	ohm-cm
	500°C d.c.	ASTM C-657	10^{7}	ohm-cm
Loss Tangent	25°C, 10 kHz	ASTM D-150	0.003	
	25°C, 8.6 gHz	ASTM D-150	0.007	
Dielectric Constant	25°C, 10 kHz	ASTM D-150	5.92	
	25°C, 8.6 gHz	ASTM D-150	5.68	
Dielectric Strength	25°C sample thickness—10 mils, a.c.	ASTM D-149, 1 kV/sec. oil: Dow Corning-200	1000	volt/mil
	25°C sample thickness—10 mils, d.c.	ASTM D-149	3000	volt/mil
Thermal				
Thermal Expansion	RT to 400°C		94×10^{-7}	/°C
	RT to 600°C		110×10^{-7}	/°C
	RT to 800°C		123×10^{-7}	/°C
Thermal Conductivity	25°C	In-House Test Comparator	0.004	$\frac{\text{cal cm}}{\text{sec cm}^2\ °\text{C}}$
	77°F		11.68	$\frac{\text{BTU in}}{\text{hr. sq. ft °F}}$
Maximum Use Temp.	Unstressed	Max. Temp. w/o change in crystal structure	1000 1832	°C °F
Mechanical				
Modulus of Rupture	25°C	ASTM C-158 modified for high temp.	15,000	psi
Compressive Strength	25°C, 10,000 lb. min.		50,000	psi
Modulus of Elasticity	25°C	Sonic Resonance Apparatus	9.3×10^6	psi
Shear Modulus	25°C	ASTM C-623	3.7×10^6	psi
Poisson's Ratio	25°C		0.26	
Knoop Hardness	25°C, 100 g	ASTM C-730	250	
Coefficient of Kinetic Friction	25°C Against Steel	ASTM D 1894 Modified For Rigid Material	.12	
	25°C Against Aluminum	ASTM D 1894 Modified For Rigid Material	.15	
	25°C Against Polished MACOR glass-ceramic	ASTM D 1894 Modified For Rigid Material	.15	
Chemical Durability				
Resistance to Acid	5% HCl for 24 hrs. @ 95°C		87	mg/cm^2 wt loss
Resistance to Acid	5% HF for 24 hrs. @ 95°C		15	mg/cm^2 wt loss
Resistance to Base	N/50 Na_2CO_3 for 6 hrs. @ 85°C		0.12	mg/cm^2 wt loss
Resistance to Base	5% NaOH for 6 hrs. @ 95°C		8.5	mg/cm^2 wt loss

When to use MACOR™ Machinable Glass-Ceramic

Technical ceramics and glasses offer extremely good mechanical, electrical, thermal and chemical performance, but their utilization has sometimes been limited because of the difficulty in fabricating parts in which precision tolerances or complicated shapes were required.
Designers are utilizing MACOR™ glass-ceramic to economically achieve these tight tolerances and complicated shapes.
MACOR™ glass-ceramic rod and plate stock is also used when fast turnaround or short runs make machining parts advantageous.

Fast Turnaround

Since MACOR™ parts can be fabricated using ordinary metalworking tools and equipment, it can be machined in the user's shop, under his control, saving time and money.
Special parts made from other ceramics or glasses can be pressed (molded) or even machined. However, both approaches are time consuming. If the part is pressed, molds must be manufactured.
If an ordinary glass or ceramic part is machined, it often must be sent to special fabricators that have the expertise and equipment necessary to grind or fire the part.

Complicated Shapes

Because MACOR™ material is very strong it can be machined directly into a complicated shape. The shapes that can be obtained by pressing a glass or ceramic part are limited and secondary machining is often required to complete the shape.

MACOR™ glass-ceramic can be machined so much more easily than these materials that it is often more economical to machine a complete part directly from MACOR™ bin stock than to press and then machine a complicated shape from ceramic or glass.
An important example is the drilling of small holes in parts (~ .030" dia.). These holes can be drilled in MACOR™ parts with a simple steel drill whereas complicated, diamond drilling techniques are required for alumina, steatite or glass.

Short Runs of Special Parts

Although pressed or molded parts are inexpensive, the tooling to make the parts is often quite expensive. Machining parts from MACOR™ rod and sheet stock may be economical considering the overall cost for a short run.

Precision Tolerances

All glasses and glass-ceramics except MACOR™ glass-ceramic need to be diamond ground to achieve precision tolerances. Although ceramics such as alumina and steatite can be machined in the green state, shrinkage during the firing process requires that they also must be diamond ground to achieve precision tolerances after firing.

Bin Stock

MACOR™ machinable glass-ceramic is designed to be machined by the user. Consequently it is available from stock in standard sizes of Rod, Bar & Sheet. (see stock/price list.)

Rough Castings

Since MACOR™ glass-ceramic is melted and formed as a glass, it is possible to preform parts (to limit the amount of machining required) by using hot glass forming techniques. After a high volume application has been established using parts machined from MACOR™ bin stock, Corning will develop special forming processes to make appropriate "rough castings" to be finished by the user.

MACOR™
Machinable Glass-Ceramic Department
Corning Glass Works
Corning, New York 14830
For more information call:
Tel: 607-974-8626

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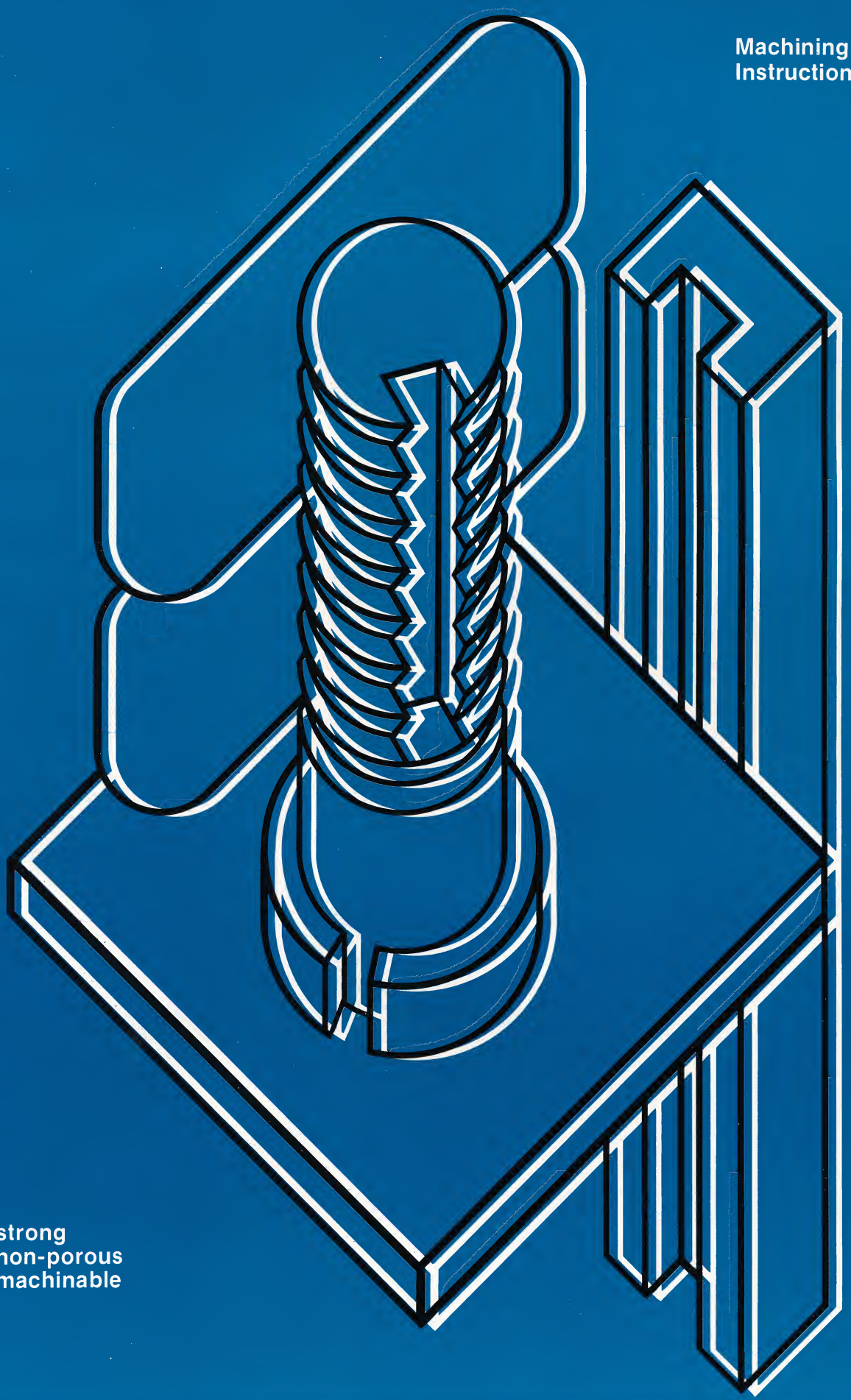
Machining Instructions



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Department
Corning Glass Works
Corning, New York 14830

MACOR™
Machinable Glass-Ceramic Code 9658

Machining Instructions

General Information

MACOR™ Machinable Glass-Ceramic is a unique glass ceramic material because it can be machined with standard metal-working tools and equipment. Firing is not required after machining.

MACOR™ materials machine differently from metals, but an experienced machinist should be able to achieve excellent results after becoming familiar with the material. The recommendations listed below should be studied before machining the material.

If any problems arise please don't hesitate to call for assistance—607 974-7288. Ask for Joe Abeel.

Coolants

It is recommended that liquid coolants be used to dissipate heat from the tool and to trap the powder that comes off during machining. Coolants that have been used successfully include Johnson's Cold Stream, Supercut S67 and Quaker 103. Water can also be used.

MACOR™ rod and sheet can also be machined dry, although it will have a greater tendency to chip. Freon should be dripped on the tool if possible to cool the tool.

Operations

	Recommended cutting speeds and feeds for Machinable Glass-Ceramic		
Turning	Cutting Speed (surface ft. per min.)		30-50
	Feed Rate (inches per revolution)		0.002-0.005
	Depth of Cut (inches)		0.150-0.250
Milling	Cutting Speed (surface ft. per min.)		20-35
	Chip Load (inches per tooth)		0.002
	Depth of Cut (inches)		0.150-0.200
Band Sawing	Band Speed (ft. per min.)		100
	Blade Type		Carbide ¼ in. wide
Drilling	Drill Size	RPM	Feed IPR
	¼ inch	300	0.005
	½ inch	250	0.007
	¾ inch	200	0.010
	1 inch	100	0.012
	2 inch	50	0.015
Polishing	Use cerium oxide on a pitch or felt cloth		
Tapping	Use kerosene as lubricant		

Tooling

Machinable Glass-Ceramic can be cut with regular high speed steel tools. Carbide tools do perform better than high speed steel and are recommended for more difficult machining operations as well as high volume applications.

Other Considerations

When these glass-ceramic materials are being machined, the stock being removed comes off in fine chips or powder. It should be noted that inhalation of any fine powder can be considered a health hazard.

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Machinable Glass-Ceramic Dept.
Corning Glass Works
Corning, New York 14830
Tel: 607-974-8626

MACOR™
Machinable Glass-Ceramic
Code 9658

Thank you for your interest in MACOR™ Machinable Glass-Ceramic. Enclosed is a technical brochure, price list and machining instructions for your study.

As you know, MACOR™ Machinable Glass-Ceramic is a relatively new Corning Glass Works' material. Numerous applications have been found and our customers are reporting new uses every day. In order to help us determine how we can best serve your material needs, your help is requested in filling out the enclosed postage paid reply questionnaire.

Thank you once again for your interest in MACOR™ Machinable Glass-Ceramic.

Very truly yours,

CORNING GLASS WORKS

William E. Felthousen

William E. Felthousen
Product Manager
MACOR™ Machinable Glass-Ceramic

WEF:mmr
Enclosure

CORNING

Machinable Glass-Ceramic Dept.
Corning Glass Works
Corning, New York 14830

MACOR™ Machinable Glass-Ceramic Code 9658

Price List

MACOR™ Machinable Glass-Ceramic is available in sheet, bar, and rod form. A wide range of standard sizes have been included to allow the user to conveniently machine his final part.

Base Prices
All base prices are per piece.

Sizes

Sheet Sizes
Tolerance on thickness:
−0″ + 1/16″
Tolerance on length and width:
± 1/16″

Thickness	Cross Section		
	3″ x 3″	6″ x 6″	12″ x 12″
½″	$ 20	$ 79	$299
¾″	30	112	446
1″	39	155	593

Bar Sizes
Tolerance on all dimensions:
± 1/16″

Length	Cross Section			
	½″ x ½″	1″ x 1″	2″ x 2″	2″ x 6″
3″	$ 5	$14	$ *	$ *
6″	10	28	*	*
12″	20	56	*	*

Rod Sizes
Tolerance on length ± 1/16″
Tolerance on diameter:
1/2″, 1″, 2″, Ø: −0″ + 1/16″
3″, 4″, 6″ Ø: ± 1/16″

Length	Diameter					
	½″	1″	2″	3″	4″	6″
3″	$10	$ 18	$ 55	$ 92	$165	*
6″	20	36	110	185	330	*
12″	40	72	220	370	660	*
24″	95	170	*	–	–	–

*Price and availability upon request.

Pricing

Discount Schedule
The following discount schedule will apply for single orders:

Gross Order Value ($)	Percentage Discount (%)
1000 – 2444	10
2500 +	Available upon request

Other Information

MACOR™ Machinable Glass-Ceramic is normally available from stock. Delivery times will be indicated at time of order entry or on the order acknowledgement.

Special lengths will be available for some cross-sections. Ask for a special quotation.

Non-standard sizes will be quoted on request. The volume required should be at least 3000 cubic inches.

Ordering Procedures

North America
Orders can be entered directly through:

Machinable Glass-Ceramic
Department
Corning Glass Works
Corning, New York 14830
Tel: 607-974-8626

or through the following sales groups:

Advanced Products
Electronic Materials
Industrial Materials

Terms: FOB, Corning, N.Y.
1% semi-monthly, net 30 days
Minimum order: $50
Prices are subject to change without notice.

International
Consult the Corning representative in your area before placing an order.